Economic and Human Dimensions Research Associates ::..
5751 North Kolb Road, Suite 40108
Tucson, Arizona 85750-3773

Adapting Models to Better Fit Reality

*Questions, Comments, and Possible Outcomes**

John A. "Skip" Laitner

Advancing NEMS' Capacity for Energy End-Use Analysis

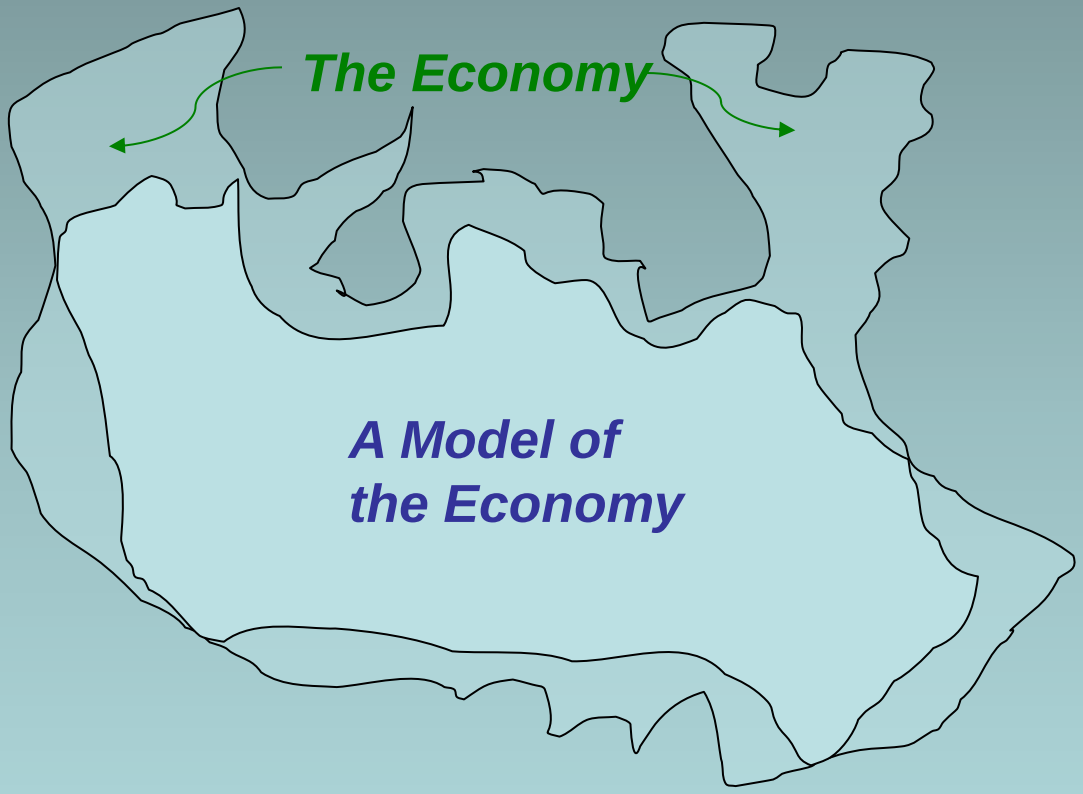
Oak Ridge National Laboratory
Georgia Institute of Technology
Washington, DC
February 26, 2013

*** In the spirit and tradition of Nobel Laureate and former Caltech physicist Richard Feynman, in his 1959 visionary talk, "There's Plenty of Room at the Bottom." See, http://www.its.caltech.edu/~feynman/plenty.html.**

All models are wrong, but some *hopefully will become* more useful than others. . . .

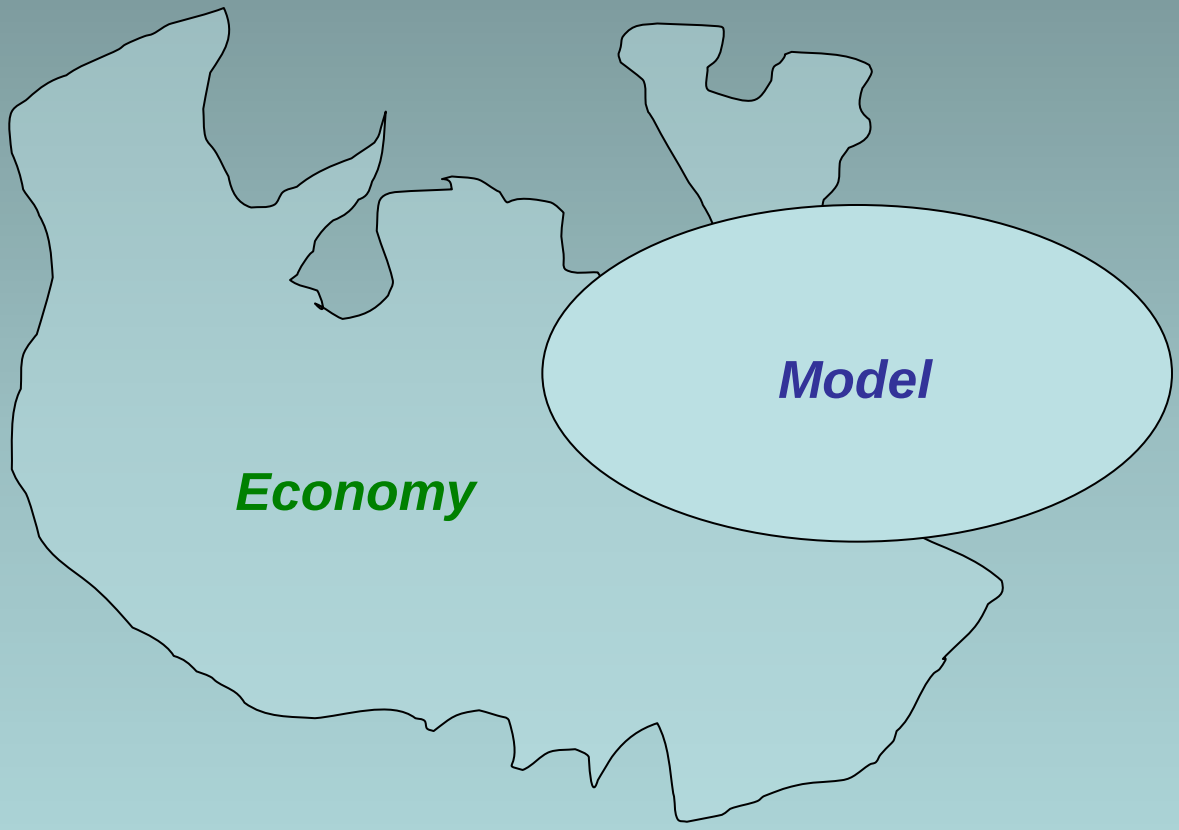
Or, what we might call The Laitner Variation on a well-known modeling commentary by George Box

The Economy: A Complex Territory, Indeed*



*Adapted and expanded from Stephen DeCanio, Presentation for the 2006 National Conference on Science, Policy, and the Environment, Washington DC. A "descriptive" and reasonably satisfying characterization that approximates reality, with detail and complexity to improve that approximation. And a "dynamic behavior" corresponding to evolution of the economy.

But What if the Model and the Economy Have Relatively Little Overlap?



Then you have results more like the recent conventional modeling exercises:
Roughly the right magnitude, but the wrong sign!

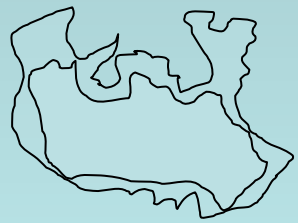
An Observation With Suggested Improvements to Help the Model Look More Like Economic Reality

My own observations since the 1992 Rio Summit (and before) suggest that, among the causes for US reluctance to move more aggressively on energy policy and climate, are modeling exercises which have preempted the assessment of a more robust set policy initiatives.

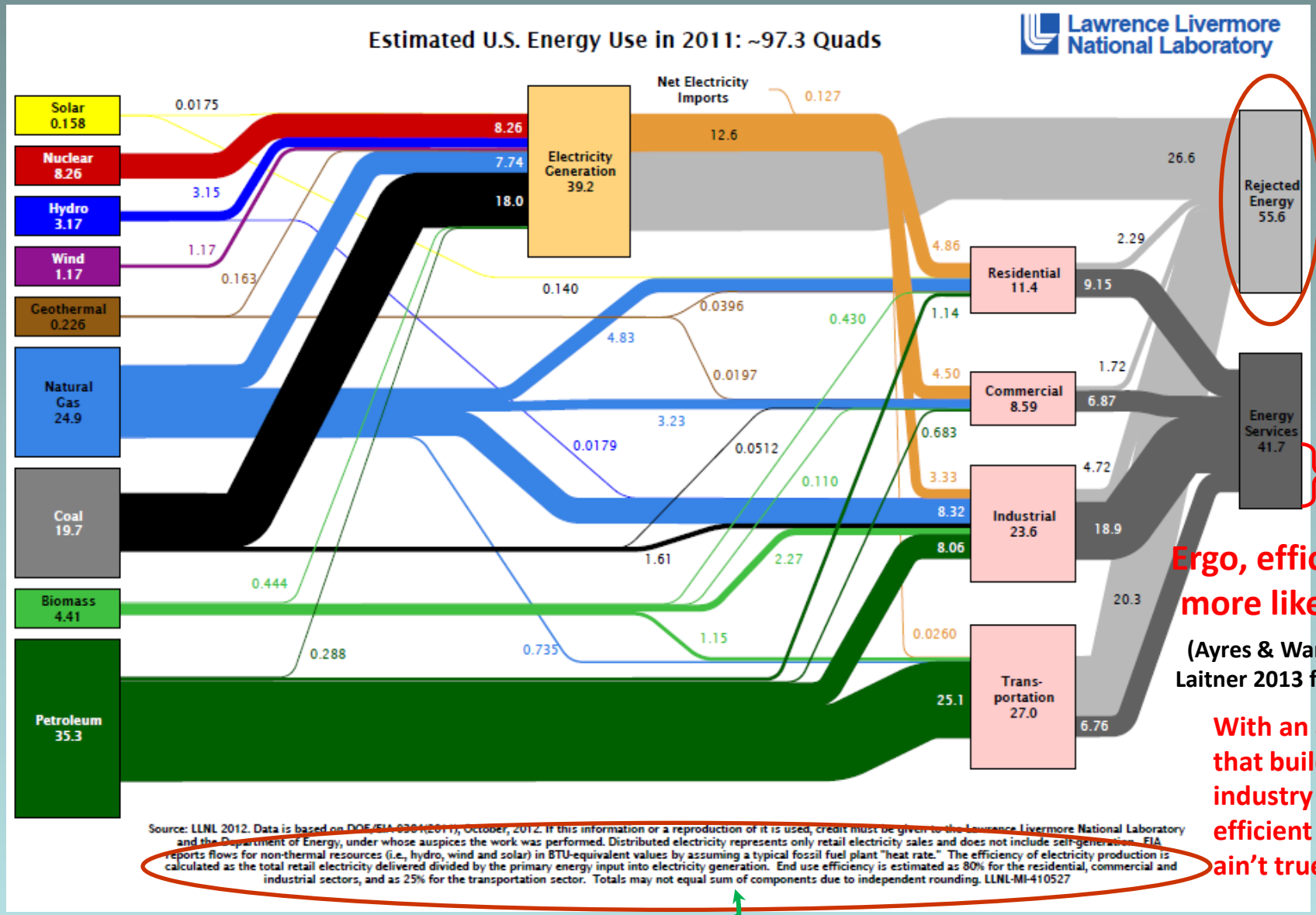
I suggest four areas of needed improvement in our modeling practices (Laitner 2009 and Laitner 2013, forthcoming):

1) ***A more dynamic review of future possibilities*** – now often a limited, and at times even inappropriate characterization of future possibilities, on both the demand and the supply-side of the equation;
2) ***Improved characterization of energy at work*** – moving beyond the tracking of formal energy as we account for production and consumption and explore useful work;
3) ***An improved economic accounting of investments*** and technology choices that highlight significant returns and productivity gains made possible by new devices, systems, infrastructure, and behavior;
4) ***What I focus mostly on here today, modeling assumptions about consumers and firms*** which reflect actual behaviors and shifting preferences rather than the reliance on fixed elasticities.

In short, prices matter, but they are not all that matter.



What is Wrong with this Picture?



Ergo, 43% efficient! But really?

useful energy

Ergo, efficiency is more like ≈ 14%

(Ayres & Warr 2009 and Laitner 2013 forthcoming)

With an assumption that buildings and industry are 80% efficient – which ain't true at all. . .

And the very fine print ?

Sometimes We Actually Do Need to Reinvent the Wheel

- In 1970 teenager Frank Nasworthy actually did reinvent the wheel and it popularized inline skating.
- Energy service companies developed new business models that expanded, for example, the deployment of CHP systems.
- And the Raspberry Pi may transform energy efficiency in new ways.

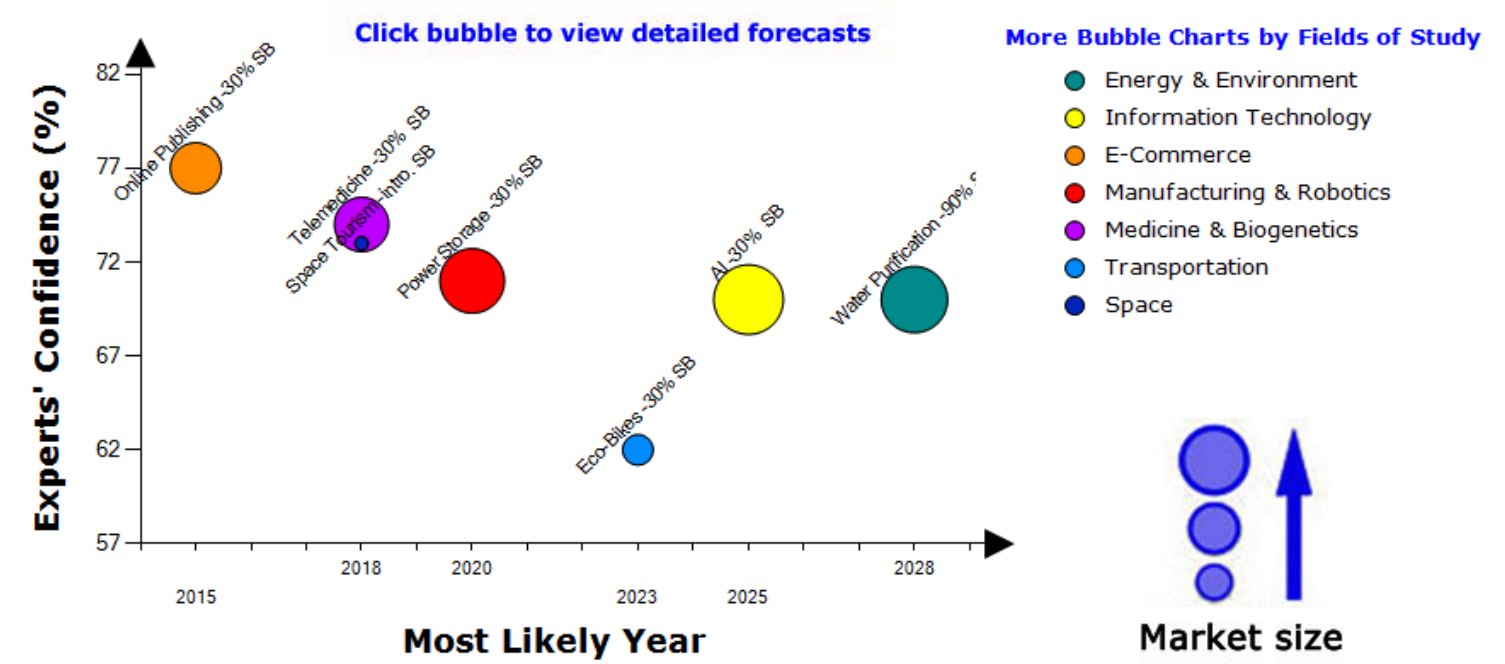
What is the Raspberry Pi?

- The University of Cambridge noticed that many PhD students in computer science had never mucked with the internal workings of a computer.
- Hence, the Raspberry Pi.

Held in my hand, a credit card-sized computer that can be plugged into your TV and keyboard. It can be used for many of the things a desktop PC does, like spreadsheets, word-processing and high-definition video games.

- I paid $53.95 on Amazon. What might that reduction in cost and size mean for prospective energy efficiency improvements? How might we model it?

Melding Time Series Data with Strategic Forecasts – Perhaps Linked by Bayesian Probabilities



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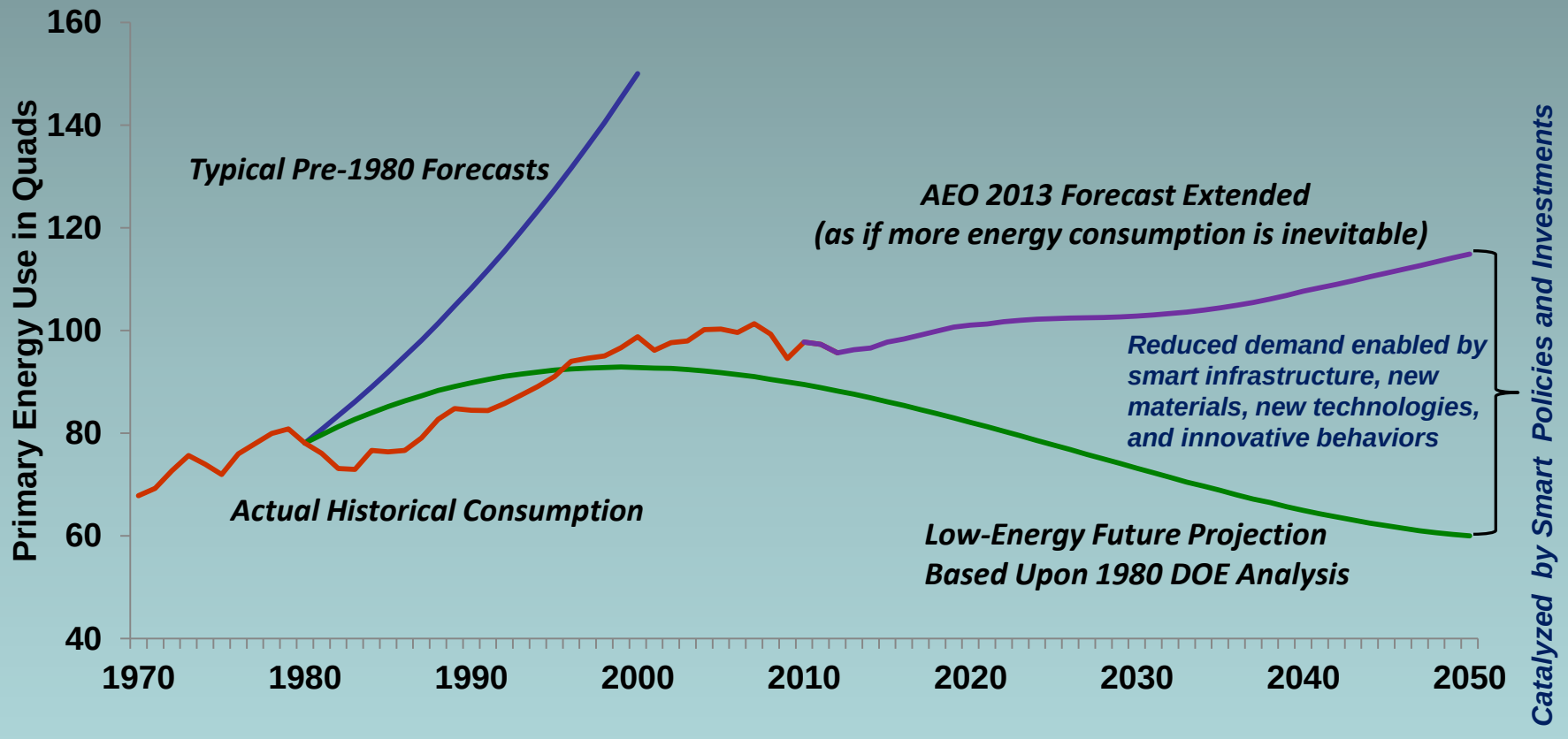
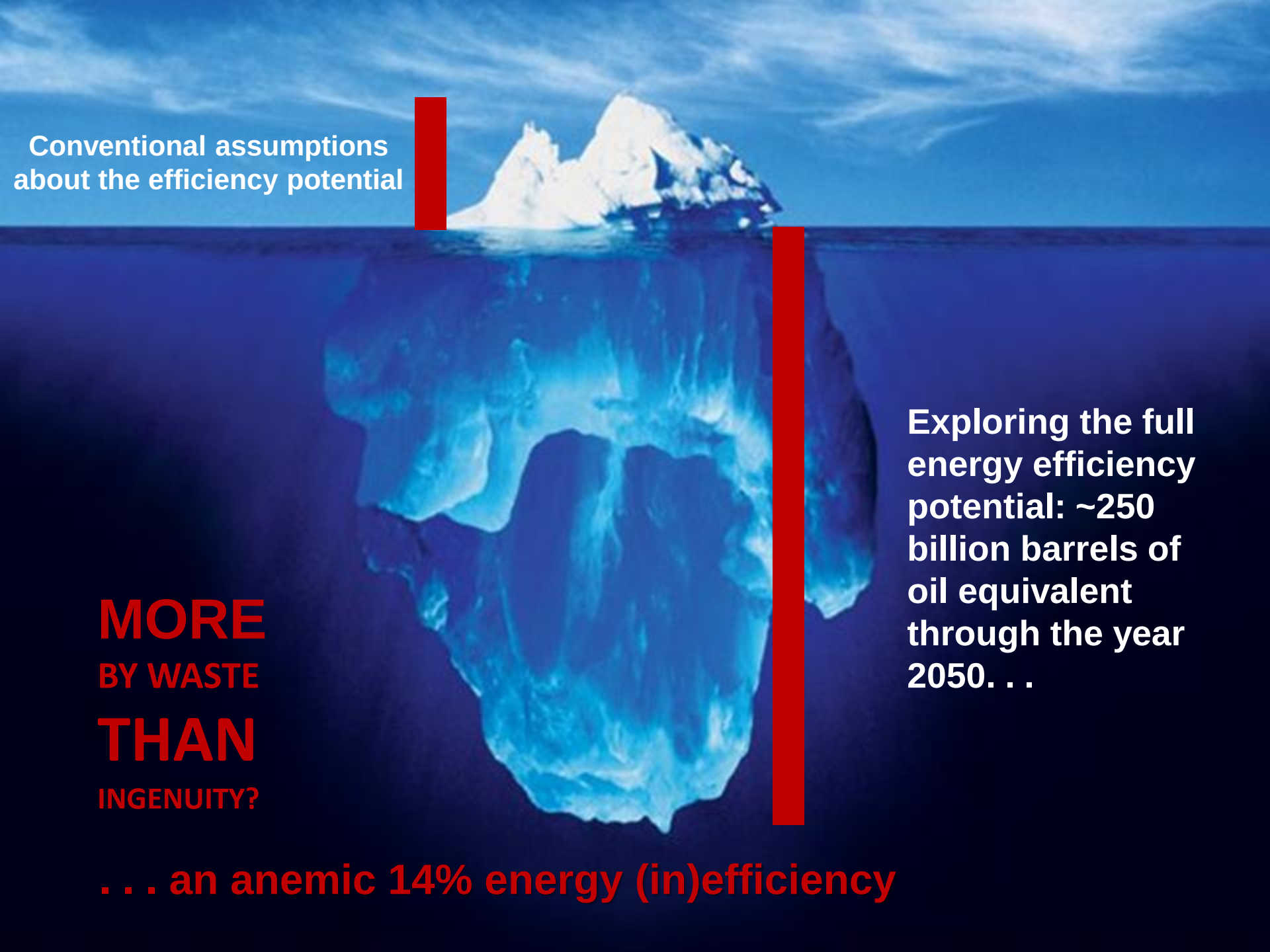
The Policy-Driven Efficiency Opportunities Are Larger than Generally Believed



Sources: DOE 1980 Policy Analysis, Annual Energy Outlook 2013, and the January 2012 ACEEE report, *The Long-Term Energy Efficiency Potential: What the Evidence Suggests*. Washington, DC: ACEEE. http://www.aceee.org/press/2012/01/aceee-report-us-better-thinking-big-


Conventional assumptions about the efficiency potential
Exploring the full energy efficiency potential: ~250 billion barrels of oil equivalent through the year 2050. . .
MORE
BY WASTE
THAN
INGENUITY?
. . . an anemic 14% energy (in)efficiency

86% OF ENERGY IS WASTED IN US

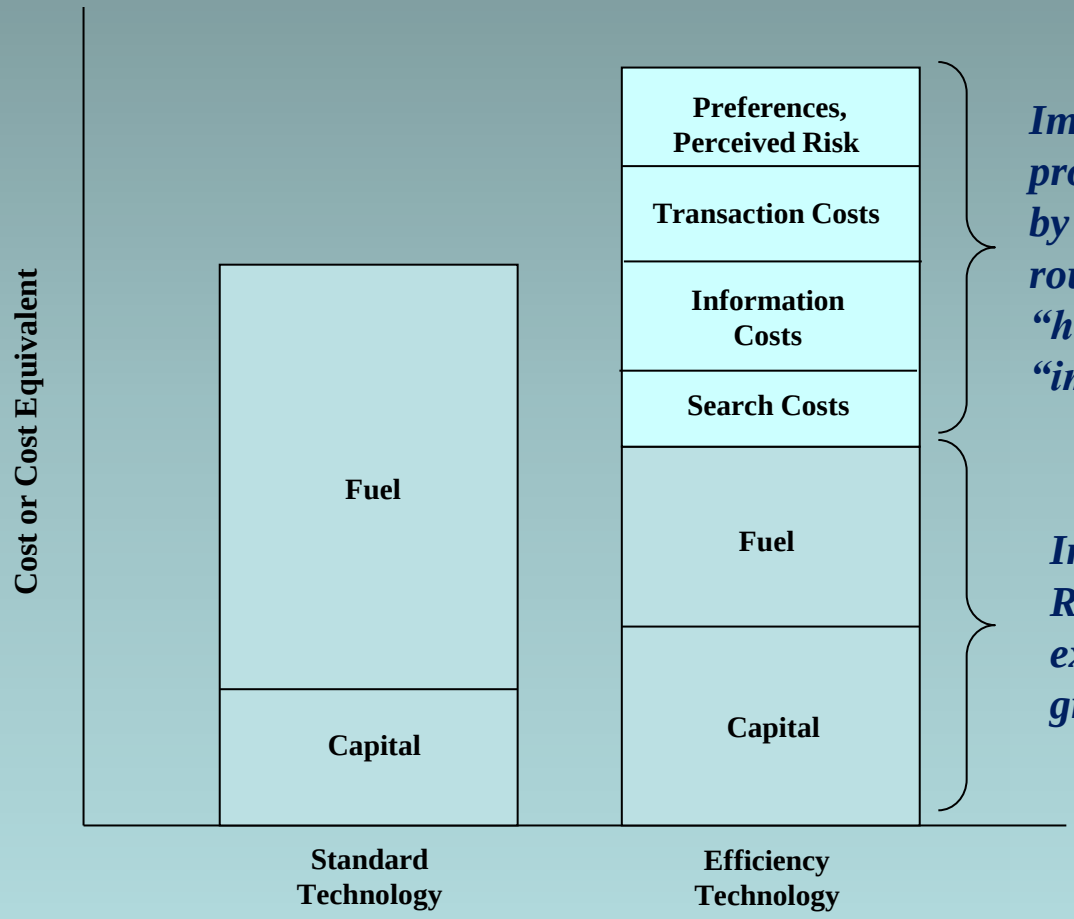
Exploring behavioral elements within a modeling construct. . . .

WE JUST HAVE TO CHANGE BEHAVIOR !

Unpacking the Elasticities: Economics Science Has Not Yet Solved…

- The very first problem – namely, what determines the price of a commodity? (Robinson 1942)
- Among things that can influence commodity prices:
  - Beliefs
  - Values
  - Habits
  - Norms
  - Alternatives
  - Necessity
  - Income
- All of which can be shaped by changed perceptions, clear and persistent policy signals, as well as new or expanding programs and policies (Brown 2001, Geller et al. 2006, and Brown et al. 2010).

Comparing Hardware and Energy Costs with "Soft" Search and Transaction Costs



Impacted by policies, programs, awareness, and by shifting preferences – all roughly approximated by the "hurdle rate" or the "implicit discount rate"

Impacted by policies, R&D programs, experience, and growing expectations

Source: Laitner 2009

In DEEPER*: The Investment Decision

Is determined by the condition:

$$\left.\frac{dK}{dE}\right|_{\bar{S}} = -P_E / r$$

A focus on the price-preference ratio

which is the point on the isoquant at which its slope and the factor price ratio are equal, i.e., the tangent point. A high value for the hurdle rate, *r*, implies that only energy-efficiency investments with a short payback will be undertaken.

But we also allow *r* to be impacted by program expenditures that we track, and under specific scenarios which we might explore, by changing consumer preferences as households and businesses become more aware of pending energy shortages and/or climate change (Laitner and Hanson 2006).

At the same time, we can also incorporate equipment and appliance performance standards as well as flexible and/or tradable CAFE permits and similar policies.

***DEEPER is the **D**ynamic **E**nergy **E**fficiency **P**olicy **E**valuation **R**outine

Jumping to the End of the Story: Diagnostic Runs with the DEEPER Model

Scenario Comparison - Year 2030	Run #1	Run #2	Run #3	Run #4	Run #5	Run #6
Emissions	CO2 Only	All Gases	All Gases	All Gases	All Gases	All Gases
Target Reduction	45%	45%	45%	45%	45%	45%
Policy Levers	Price Only	Price Only	Price/Tech	Price/~2Tech	Price/~2Tech	Price/~2Tech
Hurdle Rate Start	30%	30%	30%	30%	30%	30%
Hurdle Rate End	30%	30%	30%	30%	25%	20%
Year 2030 Results						
Emissions Price ($/tCO2e)	$268	$188	$145	$107	$65	$25
Quad Savings	36%	29%	33%	36%	41%	47%
Price Increase	100%	70%	54%	40%	25%	11%
Expenditure Increase	27%	21%	4%	-11%	-26%	-41%
Ref Case Emissions	6,640	7,956	7,956	7,956	7,956	7,956
Pol Case Emissions	3,630	4,352	4,331	4,309	4,309	4,309
Emissions Reductions	45%	45%	46%	46%	46%	46%
PolCase Cum Invest (Bln $2007) *	1,681	1,223	1,479	1,766	2,115	2,633
Start Year Payback	2.95	2.95	3.08	3.14	3.14	3.14
Last Year Payback	6.08	3.17	6.64	6.94	7.44	8.61

Just where do we get these values?

Working Review of Program Effectiveness

Program Mechanism	Reduction in Energy Consumption	Study
Feedback	10-30%	Winker and Winett 1982
	36%	Hackett 1987
Feedback and Commitment	10 – 30%	Hutton et al. 1986 (and others)
Residential Feedback	4-12%	Ehrhardt-Martinez et al. (2010)
Energy Audits	+	
Information Programs	0-9%	Collins et al. 1985
Financial Incentives*	24-35%	Katzev and Johnson 1987
	4-28%	Collins et al. 1985
Convenience Disincentives	33%	Van Houten et al. 1981
Financial Disincentives	67%	Kohlenberg et al. 1976
Group Contingencies	5-15%	Katzev and Johnson 1987
Modeling	17%	Winett
Commitment and Feedback	15%	Becker 1978
Multiple Request Compliance	+	Katzev and Johnson 1983, 1984
Social Norms	+	Schultz et al. 2007
Social Marketing	19%	Cullbridge Marketing and Communications 2007
Other Combined Programs Energy Star	4% nationally	EPA 2006a

Source: Ehrhardt-Martinez 2009

And where else do we get such data?

By our collective, informed and learned judgment, but not necessarily through the availability of quality time series and/or case study data to help integrate the social and behavior aspects into our energy models. . . .

Hence the critical need for better and coordinated research and for a more complete data collection and assessment. . . .

The difficulty lies not with the new ideas, but in escaping the old ones. . . .

John Maynard Keynes

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THE DIFFICULTY IS TO ESCAPE THE OLD IDEAS

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Note: Other citations can be provided on request.

Contact Information

John A. "Skip" Laitner
Principal Economist and Consultant
Economic and Human Dimensions Research Associates
Tucson, Arizona 85750
c: (571) 332-9434
Email: EconSkip@gmail.com

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Supplemental Slide: the Investment Decision in the DEEPER Model

(1) Testing the Equation:

$$\left.\frac{dK}{dE}\right|_{\bar{S}} = -P_E / r$$

(2) Based on the Following Data:

	Old	New	delta
***K* =**	100	130	30
***E* =**	10	9	-1
***Pe* =**		10	
***dK / dE* =**			-30

(3) With these Intermediate Results:

If Desired Payback =	2	3		3.75
***then, Pe* =**	15	10	**or**	8
***and r* =**	0.500	0.333		0.267
-P / r =	-30	-30		-30
(4) Does dK / dE = -P / r ?	**TRUE**	**TRUE**		**TRUE**